BioSentinel: Leading the Way for Deep Space CubeSat Missions

Flagship science missions are not alone in Deep Space thanks to BioSentinel, a 6U spacecraft launched on Artemis-1. BioSentinel is one of the longest operating CubeSats beyond cislunar space. The subsystems and COTS components of the BioSentinel bus are a template for future deep space missions, and the lessons learned from over a year of operations will enable improved performance for the next missions.

BioSentinel achieved its unprecedented performance for an SLS secondary payload due to preparation, planning, and a robust design. Pre-launch antenna and interface testing with both DSN and ESA confirmed command and data pathways and allowed for operational flexibility in the critical early hours post-deployment. Mission Operations simulations prior to launch identified potential risks and primed operators to respond in flight, preparing the team to react quickly to successfully detumble the spacecraft and enter a power-positive state. The spacecraft would not have survived without the inclusion of the trailblazing 3D-printed composite cold gas propulsion system. The non-standard tank geometry enabled efficient use of the limited space available in the CubeSat, as well as the capability to detumble the spacecraft and manage momentum, while providing sufficient margin to execute potential delta-V maneuvers.

The Iris radio has operated for over 18 months with no significant issues. Initial Iris performance estimates have been accurate throughout the mission. BioSentinel continues to collect data on thermal conditions and to validate our performance models with real-world knowledge. We have received exemplary support from our DSN partners.

Following the conclusion of the primary science mission, the Linear Energy Transfer (LET) Spectrometer continued to collect solar and galactic radiation data from its location in heliocentric orbit. The free space dataset offered by the BioSentinel LET is a valuable source of data for model validation and future mission planning. As the spacecraft travels farther from Earth it is poised to provide longitudinally distributed measurements of solar particle events during solar maximum.

The lessons learned from BioSentinel suggest key areas to enhance performance. The ability to upload modified flight software can increase the stability of memory management. Additional heaters in the propulsion system design have already proven successful on the Starling mission. Streamlining mission operations can reduce costs, increase data return, and better utilize DSN time. Enhancements such as these will facilitate reliable, long-duration deep space exploration using the proven BioSentinel 6U CubeSat bus.